12. (Amended) A crystal growing method characterized in that a melt control method as claimed in claim 1 is used to grow a crystal by virtue the Czochralski method.

14. (Amended) A crystal growing method characterized in that a melt control method as claimed in claim 1 is used to grow a crystal by virtue the Floating Zone method.

REMARKS

Reconsideration of this application, as amended, is respectfully requested.

Initially, the Examiner objects to claims 4-14 under 37 C.F.R. §1.75(c) as being in improper form because a multiple dependent claim should refer to other claims in the alternative only, and/or, cannot depend from any other multiple dependent claim. Applicants respectfully submit that the claims have been amended to comply with the Examiner's objections, and it is respectfully requested that the objection to the claims be withdrawn.

Claims 1-3 are rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Specifically, the Examiner states that "predetermined" is indefinite in the limitation "a predetermined atmosphere" in line 2 of claim 1, and likewise in line 4 of claim 1 for a "predetermined state". Claim 1 has been amended so that "predetermined" has been deleted from the claim. Accordingly, it is respectfully requested that the rejection of claims 1-3 under 35 U.S.C. §112, second paragraph, be withdrawn.

The Examiner rejects claims 1-3 under 35 U.S.C. §102(b) as being allegedly anticipated by U.S. Patent No. 4,400,232 to Ownby et al. (hereinafter "Ownby"). Specifically, the Examiner states that Ownby discloses that oxygen related defects occur in the production of single crystal

silicon from molten silicon, and that oxygen and carbon related defects can be controlled and reduced through deliberate addition of an oxygen containing buffering gas to the silicon processing chamber and maintaining the oxygen partial pressure. The Examiner states this is read on Applicant's control of one specific element contained in the atmosphere.

Ownby discloses oxygen and carbon related defects in the production of silicon crystals and teaches that the oxygen related defects could be decreased if the oxygen partial pressure is lower than about 10^{-6} atmosphere. However, as recited in claim 1, a method that inhibits the Marangoni convection (convective motion induced by local variations of surface tension along a liquid free surface) that occurs in the semiconductor melt is not provided in Ownby. The object of the present invention is to provide crystals free from striation (growth stripes) occurring during silicon growth. The striation results from irregular temperature fluctuation occurring in the melt. In the cited reference, it is impossible to suppress the irregular temperature fluctuation in the melt, which inhibits uniform crystal growth.

The present invention, as recited in claim 1, includes controlling a physical quantity of one specific element in the atmosphere so that the Marangoni convention occurring in the semiconductor melt is inhibited. Ownby teaches that the presence of carbon dissolved in, or in the environment of, molten silicon, reduces the oxygen partial pressure by reaction with the oxygen (Col.2, lines 4-10). Ownby further states that such a method increases the amount of oxygen that can be tolerated in the ambient gas, but does not teach that by increasing the oxygen partial pressure, the surface tension of the silicon melt can be reduced.

The present invention reduces the surface tension of the silicon melt and suppresses the Marangoni convection occurring on the surface by controlling a physical quantity of one specific element in the atmosphere. Ownby teaches that the presence of carbon dissolved in molten

silicon reduces the oxygen partial pressure by reaction with the oxygen. Anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim. Lindeman Maschinenfabrik GMBH v. American Hoist and Derrick Company, 730 F.2d 1452, 1458; 221 U.S.P.Q. 481, 485 (Fed. Cir. 1984). Ownby does not teach each element of claim 1; therefore, the anticipation rejection under §102(b) is improper.

The Examiner further rejects claims 1-3 under 35 U.S.C. §102(b) as being allegedly anticipated by U.S. Patent No. 5,524,574 to Huang et al. (hereinafter "Huang"). Specifically, the Examiner states that Huang discloses that a single crystal pulled from a Sb-doped Si melt and the oxygen concentration of a Si single crystal pulled from a Si melt depends on the diffusion of oxygen from the surface of the melt. The Examiner further states that Huang discloses the diffusion of oxygen from the melt to the atmosphere can be controlled by the pressure of the atmosphere, and that this reads on Applicant's controlling one specific element in the atmosphere.

Huang discloses that the oxygen concentration in the silicon crystal depends on diffusion of oxygen from the atmosphere (Col. 5, lines 44-49). However, the oxygen flow during growth includes four processes: (1) mixture of the quartz into the Si melt as a result of melting the quartz at the interface between the quartz crucible (Si02), (2) the diffusion due to a concentration gradient in the Si melt and the movement by the melt flow, (3) evaporation from the crystal growing interface into the surrounding atmosphere, and (4) evaporation from the surface of the melt into the surrounding atmosphere (pages 1-2, third paragraph).

Therefore, taking into account the oxygen flow as a whole, not only the influence of the diffusion as stated by Huang, it is submitted that the oxygen flow is mainly dominated by the

convection of the silicon melt, i.e., the mass transfer. The present invention, by increasing the oxygen partial pressure in the Ar gas, and selecting the oxygen partial pressure to be not lower than 1.8 E (-5) MPa, decreases the surface tension of the silicon melt and suppresses or inhibits the Marangoni convection. Thus, by the discovery of the oxygen partial pressure dependency of the Marangoni convection, it is now possible in accordance with the method of the present invention to control the flow of the melt surface and to provide high-quality silicon crystals free from striation. The cited reference of Huang by the Examiner does not teach such a result by controlling a physical quantity of an element in the atmosphere, as does the present invention.

With respect to the §102(b) rejection, it is axiomatic that anticipation of a claim under §102 requires that the prior art reference disclose each and every element of the claim to which it is applied. In re King, 801 F.2d 1324, 1326, 231 USPQ 136, 138 (Fed. Cir. 1986). Thus, there must be no differences between the subject matter of the claim and the disclosure of the applied prior art reference.

Neither reference cited, Ownby or Huang, teach a method of melt control so that by controlling a physical quantity of one specific element in the atmosphere, will inhibit the Marangoni convection occurring in the semiconductor melt. Therefore, it is respectfully submitted that the rejection of claims 1-3 under §102(b) is improper because Ownby or Huang fail to disclose such a method, and it is respectfully requested that the rejection be withdrawn and the claims allowed.

Additionally, the Examiner states claims 4-14 have not been treated on the merits because of the objection under 37 C.F.R. §1.75(c). The multiple dependencies have been corrected and it is respectfully submitted that claims 4-14 are now in proper form and allowable, as independent claim 1 is now allowable for the above-stated reasons.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached pages are captioned "**Version with markings to show changes made.**"

In view of the above, it is respectfully submitted that this application is in condition for allowance. Accordingly, it is respectfully requested that this application be allowed and a Notice of Allowance issued. If the Examiner believes that a telephone conference with Applicants' attorney would be advantageous to the disposition of this case, the Examiner is requested to telephone the undersigned.

Respectfully submitted,

Paul J. Esatto, Jr.
Registration No. 30,749

SCULLY, SCOTT, MURPHY & PRESSER
400 Garden City Plaza
Garden City, New York 11530
(516) 742-4343

PJE:AVS:gmj

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 1, 4, 5, 8, 9, 10, 11, 12 and 14 have been amended as follows:

1. (Amended) A melt control method [which is for use in controlling the] wherein a state of a semiconductor melt surrounded by [a predetermined] an atmosphere [, characterized in that one component] is controlled by controlling a physical quantity of one specific element in the atmosphere [is controlled] so as to [be in a state, thereby controlling the] inhibit Marangoni convection occurring in the semiconductor melt.

4. (Amended) A melt control method as claimed in [claims 1 to 3] claim 1, wherein the one specific element is oxygen.

5. (Amended) A melt control method as claimed in claim [4] 2, wherein the one specific element is oxygen and an oxygen concentration is controlled on the [crucible/melt] interface between the crucible and the melt, while an oxygen partial pressure on the melt surface is controlled in the opening of the crucible.

8. (Amended) A melt control method as claimed in [claims 5 to 7] claim 5, wherein the atmosphere covering the melt surface is an argon gas atmosphere having a controlled oxygen partial pressure.

9. (Amended) A melt control method as claimed in [claims 5 to 8] claim 5, wherein the oxygen partial pressure is monitored by an oxygen detector and such an oxygen partial pressure is adjusted.

10. (Amended) A melt control method as claimed in [claims 5 to 9] claim 5, wherein the oxygen partial pressure is in a predetermined state having a pressure of not less than 1.8 E (-5) MPa.

11. (Amended) A melt control method as claimed in [claims 1 to 10] claim 1, wherein a buoyancy convection other than the Marangoni convection is inhibited.

12. (Amended) A crystal growing method characterized in that a melt control method as claimed in [claims 1 to 11] claim 1 is used to grow a crystal by virtue the Czochralski method.

14. (Amended) A crystal growing method characterized in that a melt control method as claimed in [claims 1 to 11] claim 1 is used to grow a crystal by virtue the Floating Zone method.